Heavy metal content in aquatic organisms of Lake Toya and risk assessment for human health

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[Background and purpose]

Heavy metal contamination can be caused by natural and anthropogenic sources. It is recognized that the Japanese archipelago has been affected by volcanic activity emitting heavy metals as a natural source of contamination. The aquatic organisms in the Lake surrounded by or near volcanic areas can contain high amounts of heavy metal as a result of bioaccumulation and biomagnification and it is considered to cause a potential risk for human beings by being consumed as food. Lake Toya locates in the southwestern part of Hokkaido, which is formed by caldera and surrounded by the active volcano. The purposes of this study are to establish an IC platform for the determination of heavy metals in biological samples and to measure the heavy metal contents in aquatic organisms of Lake Toya for evaluating the human health risks by consumption of the aquatic organisms.

[Method]

Lake waters, sediment, and three aquatic organisms (*Oncorhynchus nerka, Hypomesus nipponensis, Palaemon paucidens*) of Lake Toya were collected or purchased. Water and sediment samples were stored in the refrigerator and the biological samples were stored in the freezer until analysis. The microwave acid digestion method was applied to the decomposition of sediment and biological samples. Then, ion chromatography with post-column derivatization method (IC) was applied for the separation and detection of heavy metals.

[Results and discussion]

It was confirmed that the IC method proposed in this study can simultaneously separate and measure five heavy metals including Pb, Cu, Zn, Ni, and Co. By applying the microwave acid digestion method, it is possible to determine the content of heavy metals below 1 μg/g in hundreds of micrograms for the biological sample and to confirm the accuracy of the method using the standard reference material. The order for the averaged Cu content in three aquatic organisms was *Palaemon paucidens* > *Hypomesus nipponensis* > *Oncorhynchus nerka*, while that for Zn was *Hypomesus nipponensis* > *Palaemon paucidens* > *Oncorhynchus nerka* (Fig. 1 and Table 1). Due to the bottom-dwelling habit, *Palaemon paucidens* directly contact with the bottom for feeding, while *Oncorhynchus nerka* and *Hypomesus nipponensis* are benthopelagic fish, which float in the water column. In addition, the order of averaged concentrations of Cu and Zn in *Hypomesus nipponensis* was gill> internal organs > muscle (Table 1). It can primarily be attributed to the differences in the physiological role of each organ and regulatory ability. Using the upper tolerable daily intakes of Zn and Cu for 40 and 10 mg, respectively, the maximum allowable number of each aquatic organisms were $N = 1$ of *Oncorhynchus nerka*, 4 of *Hypomesus nipponensis*, and 5 of *Palaemon paucidens* for an adult per day (Table 2).

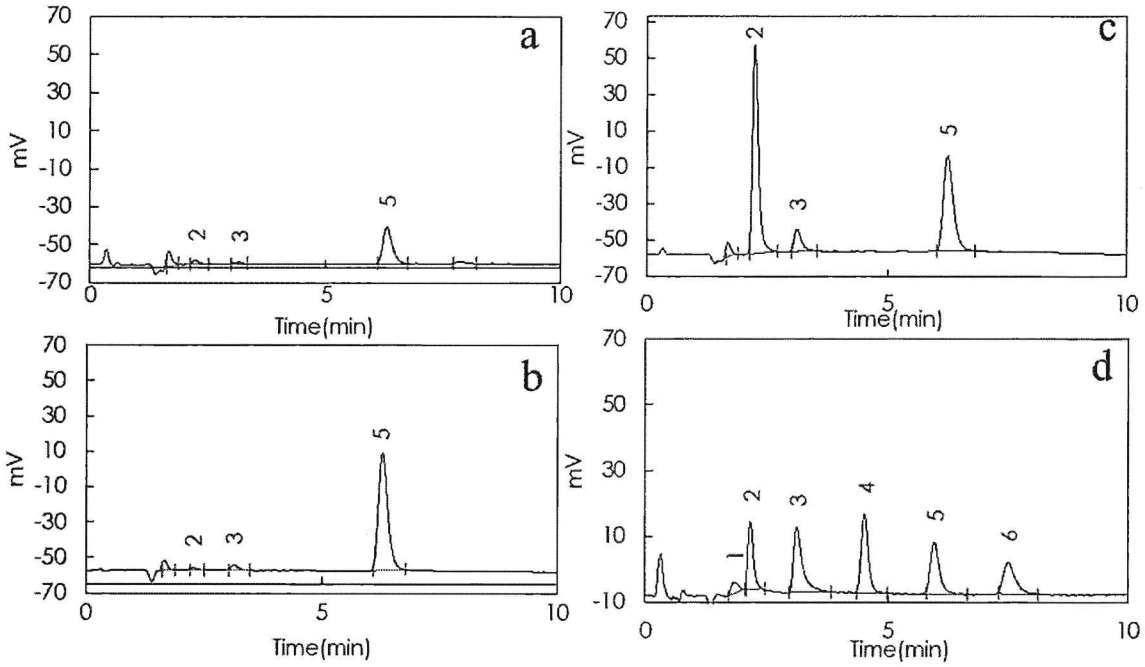

Fig. 1 Typical chromatograms for acid digested solution samples of (a) *Oncorhynchus nerka*, (b) *Hypomesus nipponensis*, (c) *Palaemon paucidens* of Lake Toya and for (d) the standard solution of heavy metals. Peak identities: 1, Pb; 2, Cu; 3, Mn and Cd; 4, Co; 5, Zn; 6, Ni.

Table 1 Heavy metal contents of aquatic biological samples in Lake Toya.

N		Concentration (μg/g wet weight)				
		Cu	Co	Pb	Zn	Ni
10	Gill	6.58±0.21	< 0.26	< 5.8	151±3.10	< 0.28
10	Internal organs	3.49±0.36	< 0.26	< 5.8	99.4±2.79	< 0.28
10	Muscle	2.83±0.10	< 0.26	< 5.8	89.8±4.80	< 0.28
2	Muscle	2.89±0.13	< 0.26	< 5.8	30.7±0.50	< 0.28
15	Whole	126±7.72	< 0.26	< 5.8	70.6±0.70	< 0.28

Table 2 The maximum allowable number of aquatic organisms of Lake Toya for an adults per day.

Scientific name	Averaged weight (g)	Cu (μg/g)	Zn (μg/g)	Maximum capacity (*N*)		Daily allowance (*N*)
				for Cu	for Zn	
Oncorhynchus nerka	120	2.9	30.7	2.8	1.1	1
Hypomesus nipponensis	10.9	3.5	89.8	11.1	4.1	4
Palaemon paucidens	1.4	126.7	70.6	5.6	40	5